

EASEP HANDBOOK FOR APOLLO 11 FLIGHT CREW

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For

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1.0 INTRODUCTION

The most compelling scientific reason for the instrumented study of the moon is the fact that the history of the earth cannot be reliably inferred unless its early relationships to the moon are known. The determination whether the moon was once a part of the earth split away by resonance-amplified tides or whether the moon is a "captured planet" is vital in tracing the evolution of the earth. By studying the moon's geology, seismology, magnetic and electrical fields and its thermal characteristics, much can be determined regarding its origin and history. Correlating this data with information known about the earth, analogies may be drawn and we may learn how the solar system, the earth and the continents on which we live were formed.

In order to obtain long-term measurements of various physical and environmental properties of the moon, complex scientific instruments have been developed for deployment on the lunar surface by Apollo astronauts. The experiments contained in the Early Apollo Scientific Experiment Package (EASEP) will remain on the moon after the return of the astronauts and will transmit scientific and engineering data to the Manned Space Flight Network (MSFN). The EASEP mission consists of two independent self-contained experiment packages; the Passive Seismic Experiment Package (PSEP) and the Laser Ranging Retro-Reflector Experiment (LRRR). In addition, the Solar Wind Composition Experiment (SWC) is included in this handbook. The PSEP contains a structure/thermal subsystem, a data subsystem, and electrical power subsystem, and the Passive Seismic Experiment subsystem. The electrical power and data subsystems are described in Section 2.0 while the experiments are described in section 3.0. Information on experiments carried on later flights is not included in this handbook.

2.0 POWER AND INSTRUMENTATION

2.1 ELECTRICAL POWER SUBSYSTEM (EPS)

The EPS provides the electrical power for lunar operation of PSEP. Primary electrical power is developed by conversion of solar energy to electrical power by the solar panel array. The solar panel array consists of six solar panels, each composed of 420 solar cells wired in a series parallel configuration to provide high reliability.

The solar panels provide 30 to 45 watts to the Power Conditioning Unit (PCU) which performs voltage conversion and voltage regulation. The PCU contains redundant power conditioners which convert the solar panel array 16 volt input to six operating voltages. In addition to controlling the output voltages, the PCU through a shunt voltage regulator radiates some of the excess power to space to prevent heating of the PSEP. All PCU output voltages are channeled through the Power Distribution Unit (PDU) which is part of the data subsystem for power switching and distribution.

2.2 CENTRAL STATION

The Central Station is a part of the Passive Seismic Experiment Package (PSEP). It is composed of the data subsystem, helical antenna, power conditioning unit, experiment electronics and the dust detector. There are provisions for thermal control of the electronics, for alignment of the antenna and electrical connections to the Passive Seismic Experiment. The following paragraphs provide additional data on some components of the PSEP.

2.2.1 Data Subsystem

The data subsystem is the focal point for control of the Passive Seismic Experiment and the collection, processing and transmission of scientific and engineering data to the MSFN. Its primary functions are:

- a. Reception and decoding of uplink commands.
- b. Timing and control of experiment subsystems.
- c. Collection and transmission of downlink scientific and engineering data.
- d. Control of the EPS through the power distribution and signal conditioner.

Figure 2.2.1-1 shows the location of the data subsystem components.

2.2.2 Antenna

The antenna is a modified axial helix designed to receive and transmit a right-hand circularly polarized S-Band signal. The antenna will be pointed to Earth by means of the antenna positioning mechanism. The antenna is manually positioned to the appropriate elevation angle corresponding to any one of the five lunar sites. Detents on the index plate retain the position. Antenna position is indicated by the index pointer and site-numbered marks on the index plate. Figure 2.2.2-1 provides a detailed view of the antenna positioning mechanism.

2.2.3 Dust Detector

The dust detector is mounted on the PSEP to obtain data for assessment of dust accretion on EASEP. The instrument is primarily composed of three solar cells, mounted on the top, and their associated electronics. The radiation environment will be measured by the reduction of solar cell output voltages due to radiation degradation of the cells. Figure 2.2.3-1 shows the dust detector.

PSEP CENTRAL STATION DATA SUBSYSTEM COMPONENTS

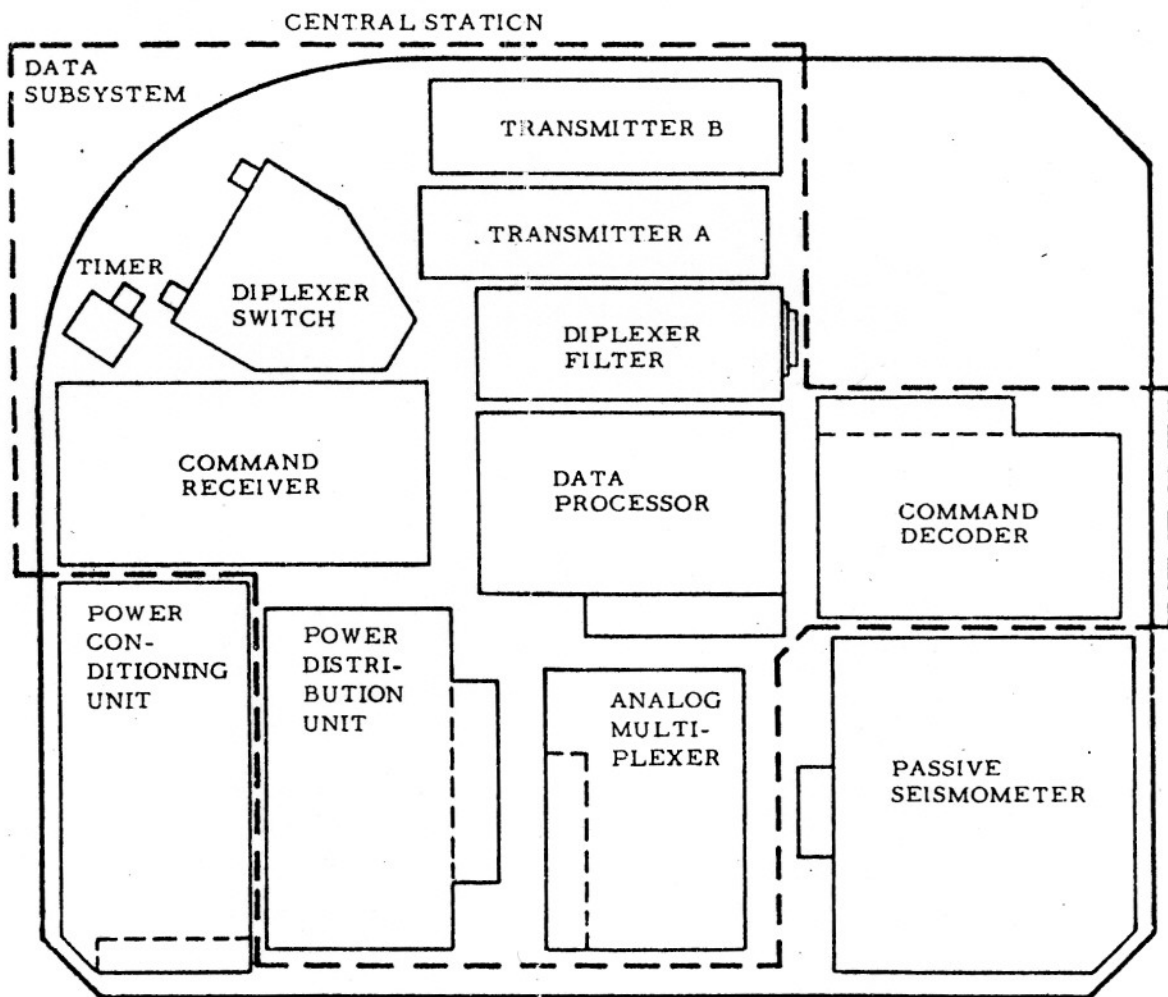


Figure 2.2.1 - 1

DUST DETECTOR

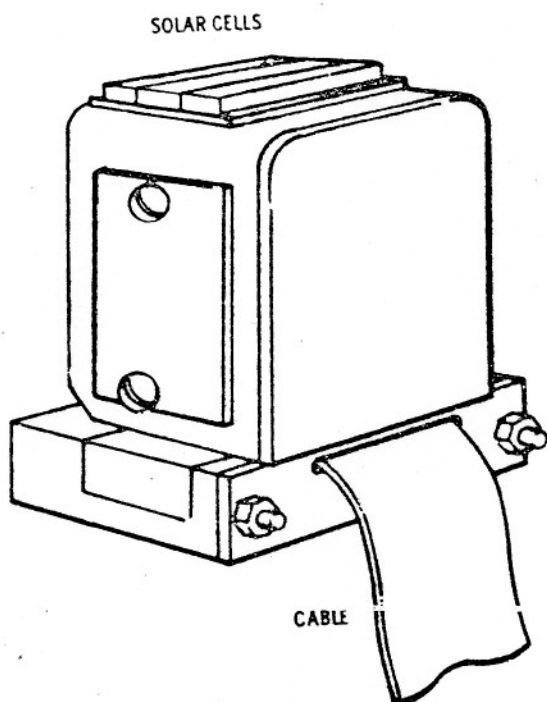


Figure 2.2.3 - 1

3.0 EXPERIMENTS

The EASEP mission is comprised of the following experiments:

<u>NASA No.</u>	<u>Experiment</u>
S031	Passive Seismic (PSE)
S078	Laser Ranging Retro-Reflector (LRRR)
S080	Solar Wind Composition (SWC)

These experiments are discussed in detail in this section and their deployment is discussed in Section 4.0. The PSEP, which includes the PSE, is deployed on the lunar surface by the astronaut. The electronic assembly provides the electrical interface with the data subsystem. The LRRR and SWC experiments are deployed individually and require no electrical connections.

3.1 PASSIVE SEISMIC EXPERIMENT (PSE)

3.1.1 Principal Investigator

Mr. Gary Latham, Lamont Geological Observatory

3.1.2 Objective

The objective of the PSE is to monitor lunar seismic activity and to detect meteoroid impacts and free oscillations of the moon.

The instrument is designed to measure elastic waves on the moon from any naturally occurring seismic event; i.e., does the moon release energy in the form of moonquakes. The question is, if the moon is active, how active; are moonquakes confined to certain regions or randomly distributed; are they shallow or deep; are they associated with certain types of surface features; what is the mechanism of energy release (focal mechanism) - rupture, sudden change in volume, etc.? From these facts something can be inferred about the internal energy regime of the moon and the nature of major crustal stress patterns that may exist.

Meteoroid impact will very likely be an important source of seismic energy on the moon. Under the most optimistic circumstances, about 1 impact per day will be recorded. Most of these will strike within 10 to 20 km of the PSEP. Under the most pessimistic circumstances, only one per month will be recorded.

3.1.3 Approach

In the study of the earth, seismic methods have proven to be the most powerful method for determining its internal structure. This method may be briefly described as follows: By measurement of the velocity with which various types of elastic waves travel through a body (body waves) and over its surface (surface waves), we can determine its internal structure. Rough locations for moonquakes or meteoroid impacts can be obtained from a single triaxial seismometer, but the power of the method is greatly increased by having two or more stations. Based on assumed lunar models, an attempt will be made to relate these events to surface features and lunar tectonics and to determine the internal structure of the moon.

Each PSE is comprised of three long period (LP) and a short period (SP) seismometer, an electrical power and a data subsystem, and a thermal control system.

In the LP seismometer, low frequency (approximately 250 to .3 second periods) motion of the lunar surface caused by seismic activity is detected by tri-axial, orthogonal displacement amplitude type sensors. Two separate outputs may be produced by each axis of the LP seismometer. The output is proportional to the amplitude of the low frequency seismic motion.

In the SP seismometer, the higher frequency (approximately 5 to .04 second periods) vertical motion of the lunar surface is detected by a displacement velocity sensor. The SP seismometer yields a seismic output proportional to seismic motion in the vertical axis of the instrument.

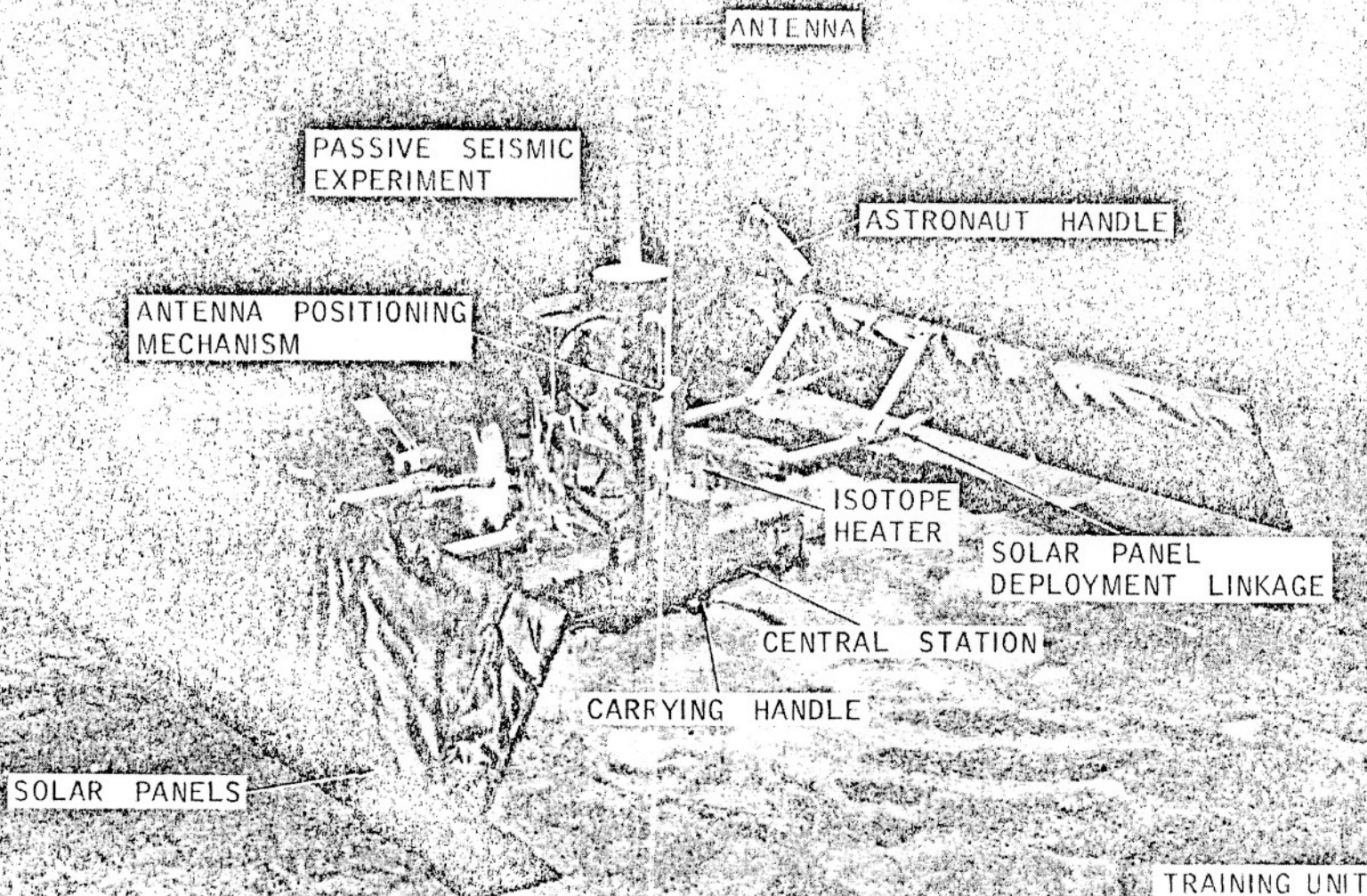
3.1.4 Experiment Description

The PSE comprises three major physical components. The sensor assembly and thermal shroud are mounted on top of the mounting plate. A separate electronics assembly is located in the PSEP Central Station, and provides the electrical interface with the data subsystem.

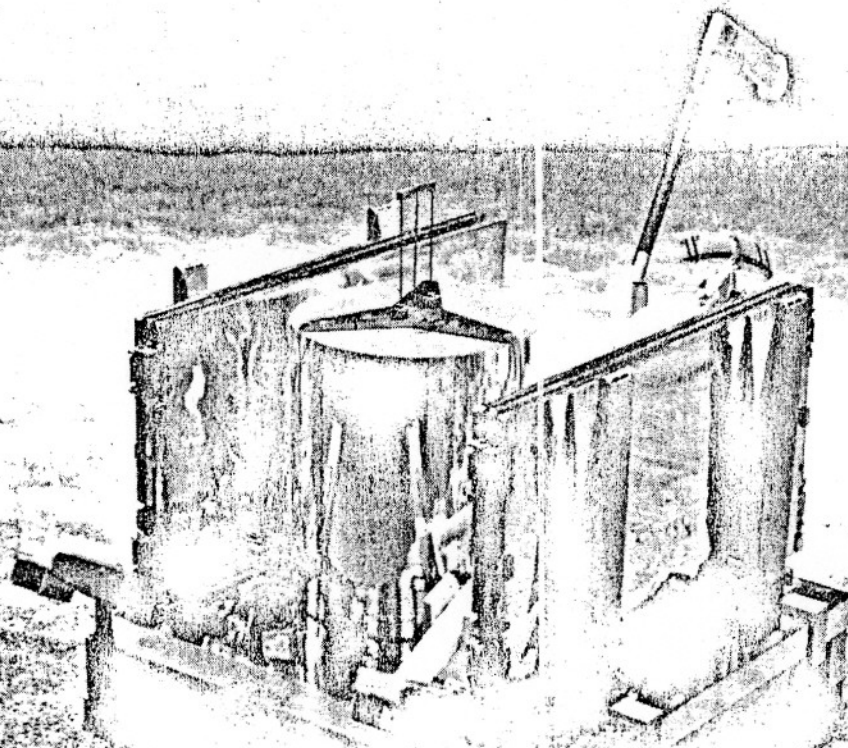
The PSE sensor assembly is generally cylindrical in form with a hemispherical base. The PSE thermal shroud has the shape of a flat-crowned hat. The crown portion covers the sensor, while the brim portion is secured to the mounting plate with velcro. Alignment is read off by azimuth gnomon and compass rose. The PSE is leveled using a ball level.

Figure 3.1.4-1 is a picture of the deployed PSEP and Figure 3.1.4-2 is a picture of the PSEP in the stowed configuration. Figure 3.1.4-3 provides detailed views of the PSE LP sensors.

PSEP DEPLOYED CONFIGURATION



PSEP STOWED CONFIGURATION

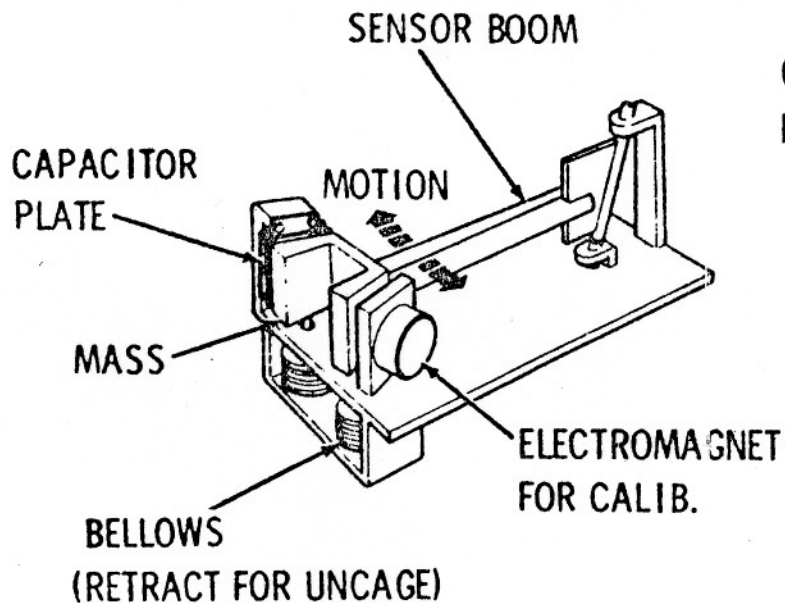


TRAINING UNIT

Figure 3.1.4-2

PSE LP SENSOR DETAILS

LP HORIZONTAL (X,Y) SENSORS



LP VERTICAL (Z) SENSOR

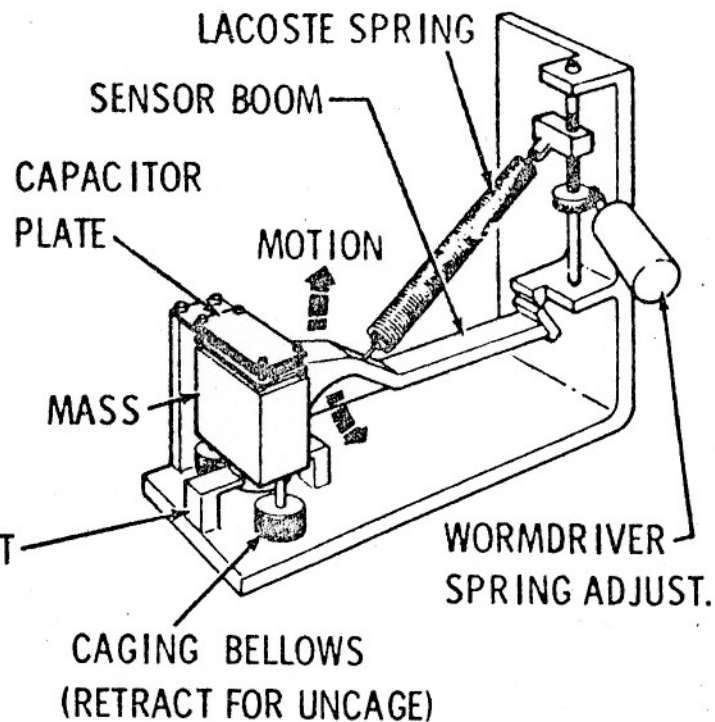


Figure 3.1.4-3

3.2 LASER RANGING RETRO-REFLECTOR (LRRR) EXPERIMENT

3.2.1 Principal Investigator

Dr. C. O. Alley
University of Maryland

3.2.2 Objective

The objective of the Laser Ranging Retro-Reflector (LRRR) Experiment is to precisely measure earth-moon distance over long time periods (up to 10 years). The data obtained will be utilized to study the following:

- a. the fluctuations in the earth's rotation rate,
- b. the wobbling of the earth on its axis,
- c. the Moon's size and orbit, and
- d. the possibility of a slow secular decrease in the gravitational constant "G".

3.2.3 Approach

The LRRR is a wholly passive experiment consisting of an array of precision optical reflectors which serve as a target for earth-based laser beams. The reflectors have the property that the angles of incidence and reflection coincide independent of the reflector's position. Since we know the speed of light and can measure in billionths of a second, it is possible to measure the time required for a beam of light to go to the moon and return and from it find the earth-moon distance within 15 centimeters.

3.2.4 Description

The LRRR consists of a retro-reflector array module and its support structure.

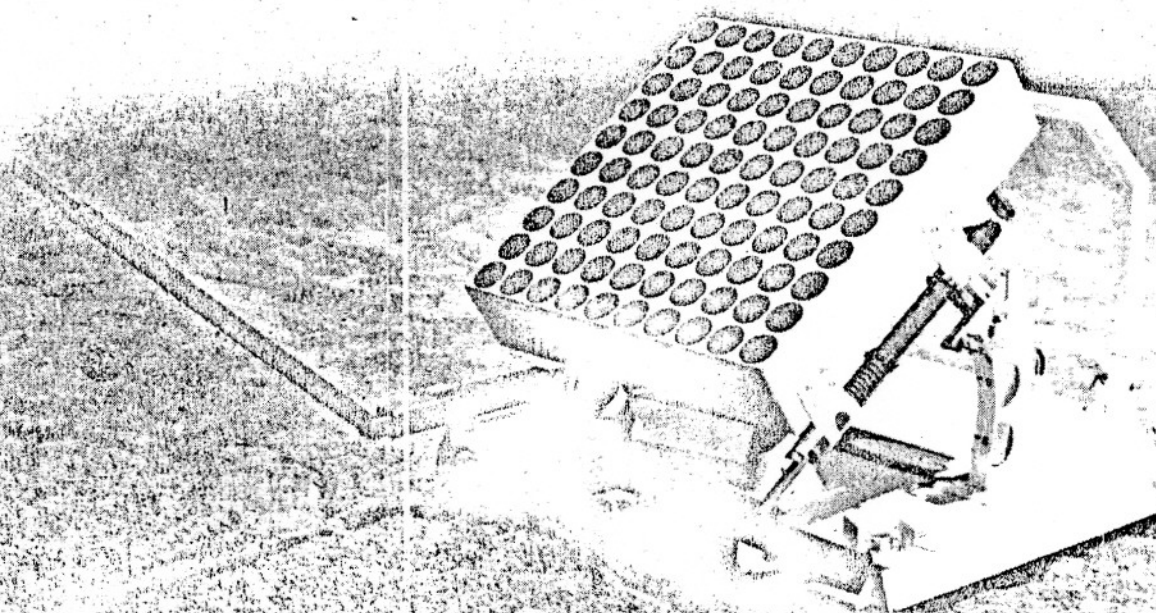
The retro-reflector array consists of a panel structure incorporating 100 retro-reflectors and an aim-angle handle. The array is mounted on a support structure which includes a pallet, alignment handle, rear support, boom attachment and aim angle bracket.

The tilt angle of the retro-reflector array is set by the aim-angle handle. The array is pivoted to the tilt angle established by holes on the aim angle bracket.

The LRRR is oriented in azimuth and leveled on the lunar surface by using the alignment handle in the fully extended position. The LRRR is positioned so that the shadow cast by the gnomon aligns with an appropriate index mark on the sun compass plate. At the same time, the bubble level is used to ensure proper leveling.

Figure 3.2.4-1 is a picture of the deployed LRRR and Figure 3.2.4-2 is a picture of the LRRR in the stowed configuration. Figure 3.2.4-3 provides a pictorial view of a retro-reflector.

LRRR DEPLOYED CONFIGURATION



TRAINING UNIT

Figure 3.2.4-1

LRRR STOWED CONFIGURATION

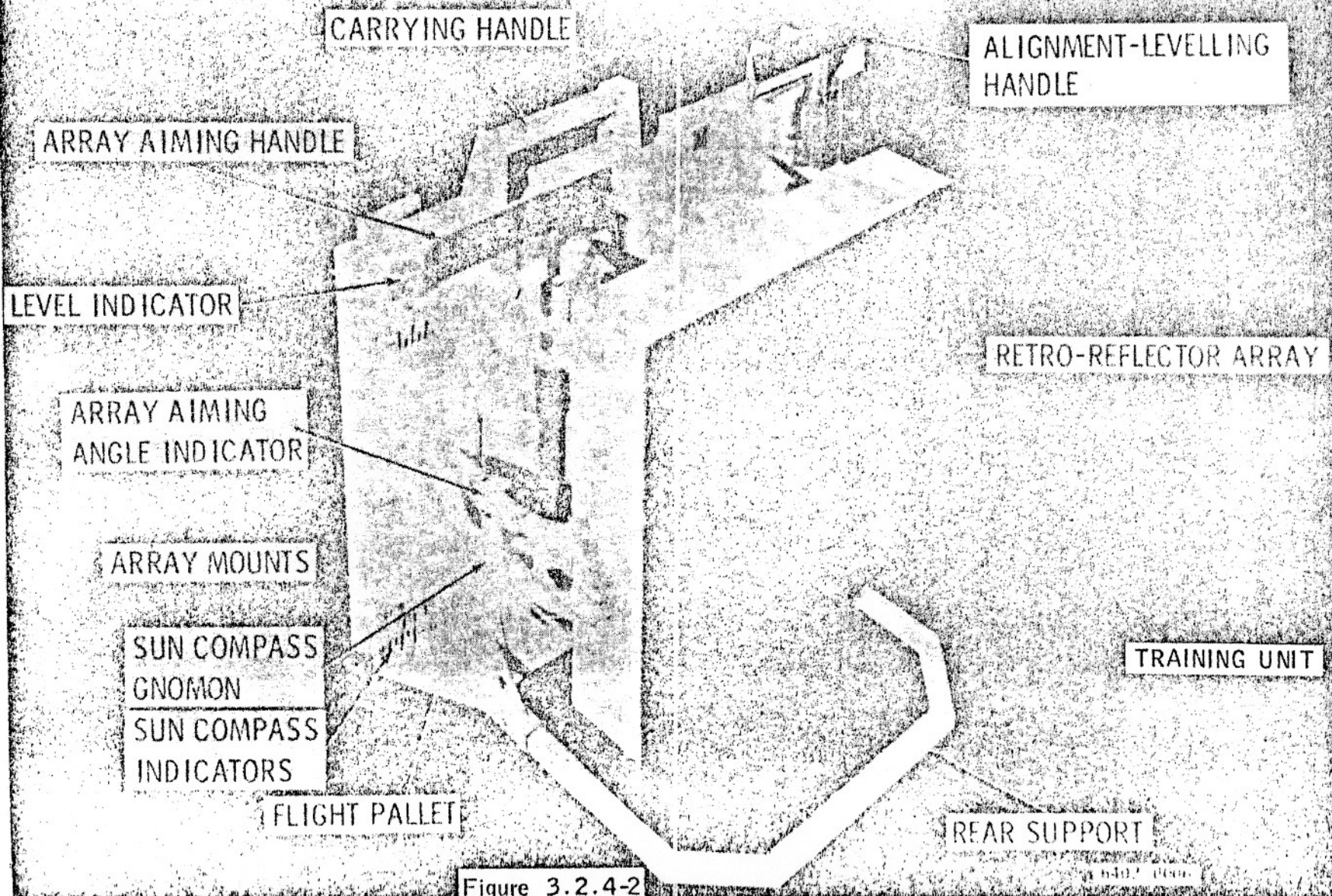


Figure 3.2.4-2

RETRO - REFLECTOR

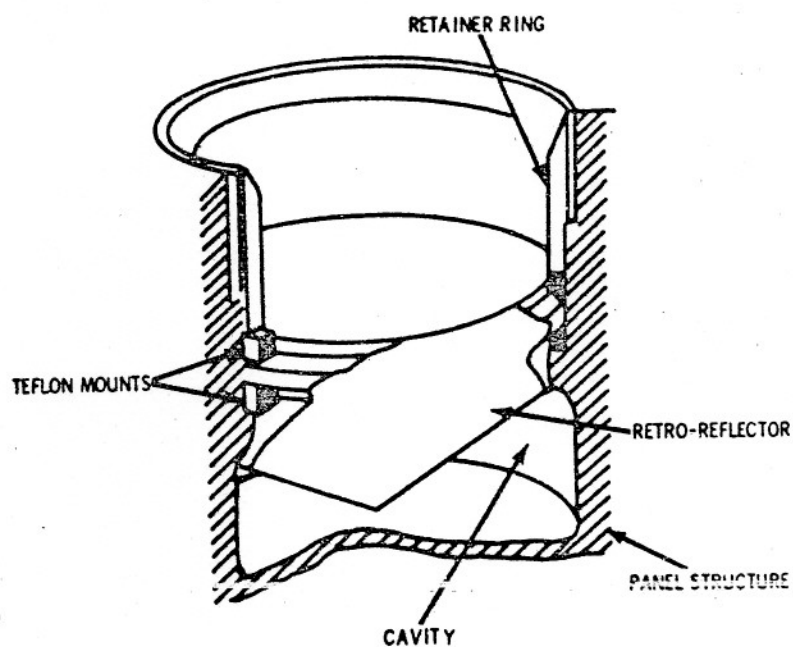


Figure 3.2.4-3

3.3 SOLAR WIND COMPOSITION EXPERIMENT (SWC)

3.3.1 Principal Investigator

Dr. Johannes Geiss
University of Berne

3.3.2 Objective

The objective of the Solar Wind Composition Experiment (SWC) is to entrap noble gas constituents of the solar wind, such as helium, neon, argon, krypton, and xenon. This data will contribute information on the origin of the solar system, history of planetary atmospheres, and solar wind dynamics.

3.3.3 Approach

A sheet of aluminum foil which is exposed to the solar wind should provide a sufficient number of trapped particles to permit the detection of the amount and the isotopic compositions of certain critical elements. When the foil is returned to earth, the collected solar wind particles will be extracted and analyzed by means of mass spectrometers and low level counting devices.

3.3.4 Description

The SWC consists of a panel of 1.5 mil thick aluminum foil rolled and assembled into a combination handling and deployment container. By means of a telescoping pole the SWC is implanted in the lunar soil for exposure to the solar wind. After completion of the experiment the foil assembly will be placed in a teflon bag and stored in the sample return container (SRC) for return to earth.

Figure 3.3.4-1 is a picture of the stowed SWC and Figure 3.3.4-2 is a picture of the deployed SWC. Figure 3.3.4-3 shows the SWC foil being rolled up on the reel.

SWC STOWED CONFIGURATION

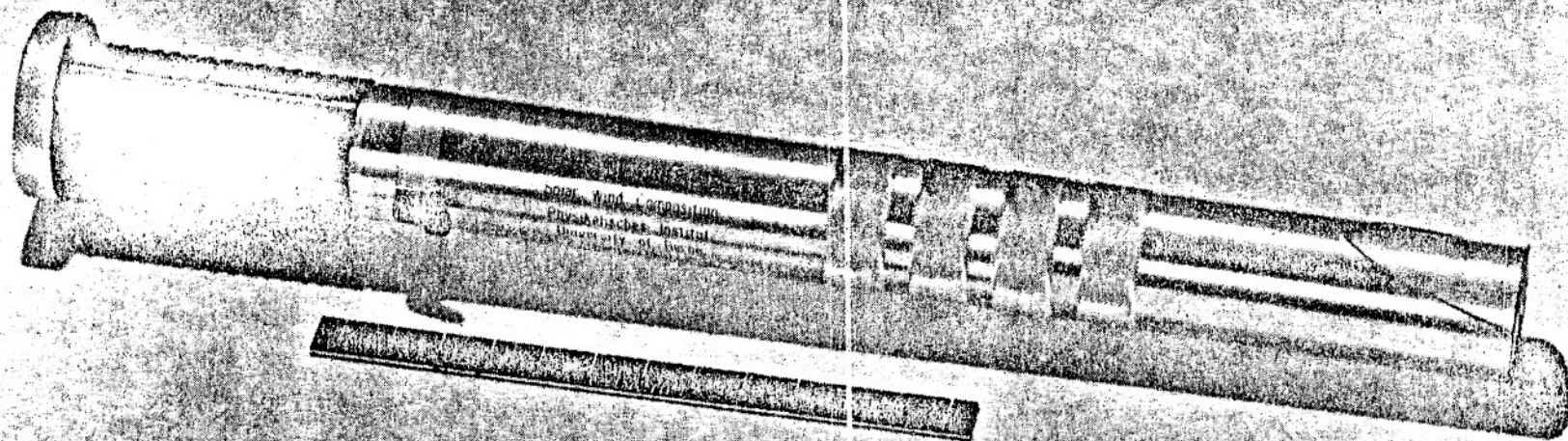


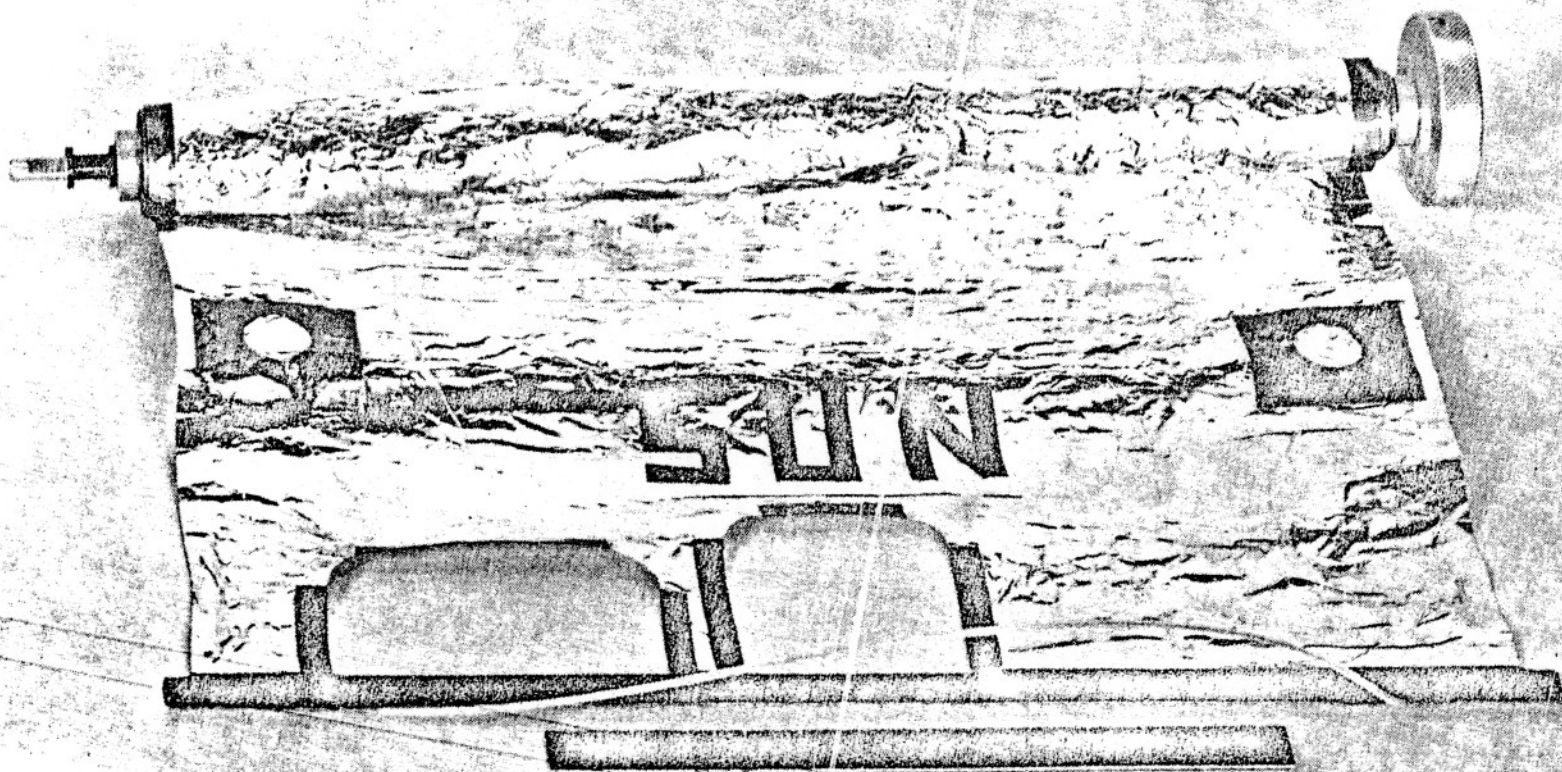
Figure 3 3 4-1

SWC DEPLOYED CONFIGURATION



Figure 3.3.4-2

SWC FOIL AND REEL



4.0 EASEP DEPLOYMENT

The EASEP is deployed on the lunar surface by completing the following tasks:

- a. Deploy and orient the SWC experiment.
- b. Remove EASEP packages from LM SEQ Bay.
- c. Transport EASEP packages to emplacement area.
- d. Deploy the LRRR and PSE experiments.

The deployment geometry and general constraints are provided in Section 4.1. Deployment procedures are covered in Section 4.2.

4.1 DEPLOYMENT GEOMETRY AND CONSTRAINTS

The EASEP deployment geometry is flexible although definite constraints exist and are defined. Figure 4.1-1 shows a very general deployment configuration. Tables 4.1-1 through 4.1-3 provide more detailed information on the deployment constraints on individual items.

EASEP DEPLOYMENT

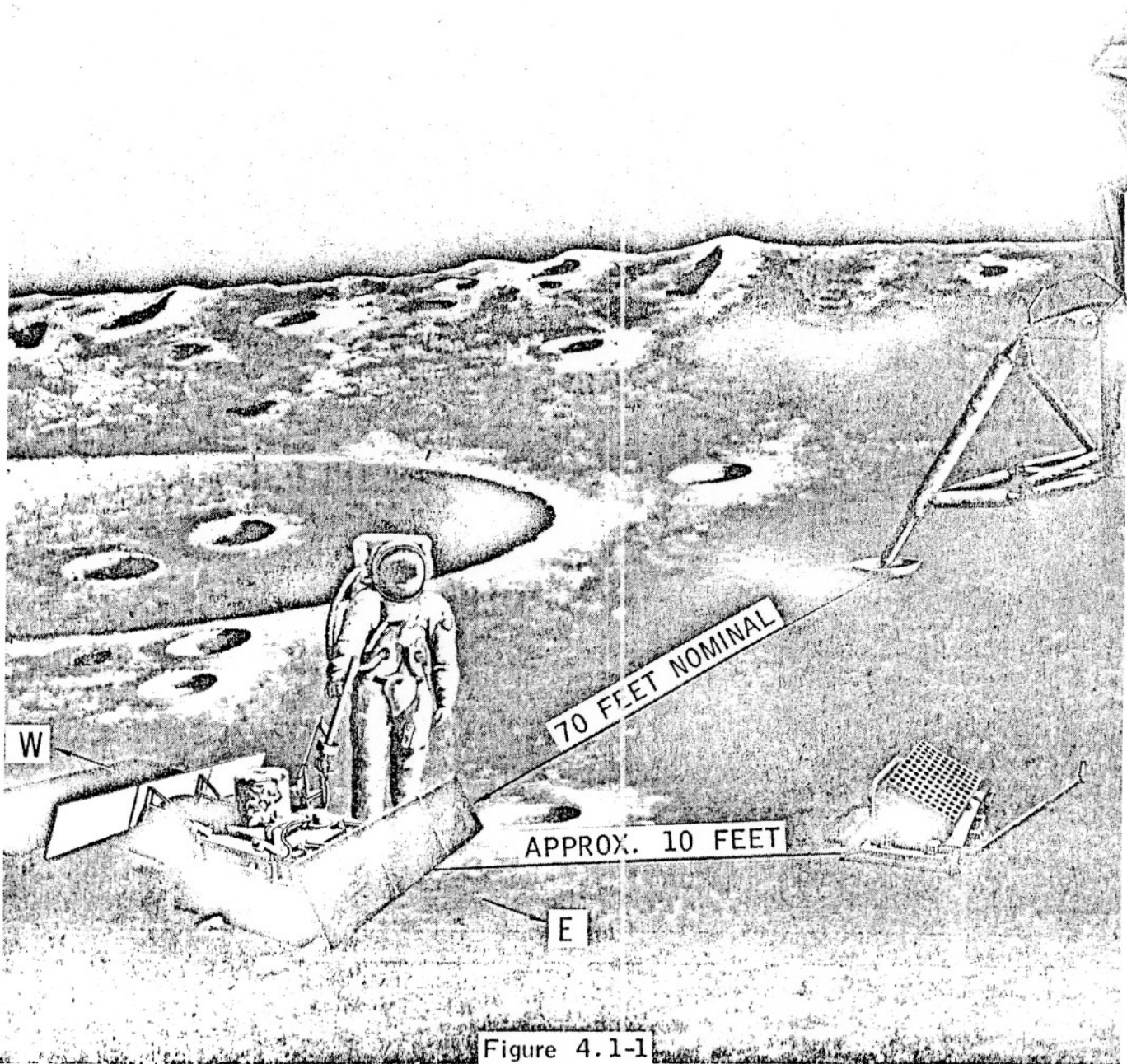


Figure 4.1-1

TABLE 4.1-1

PSEP DEPLOYMENT CONSTRAINTS

<u>PARAMETER</u>	<u>CONSTRAINTS</u>
PSEP Orientation from LM	Must not be due East or West. Astronaut must avoid walking directly into or away from sun where visibility is worst. Astronaut will visually determine direction to be chosen.
PSEP Deployment Site	70 feet nominal from LM. Area to be free of loose material and approximately level as visually determined by astronaut. Avoid craters and slopes which would degrade thermal control of unit.
PSEP Leveling	Must be coarse leveled by astronaut within ± 5 degrees of vertical because 5 degrees is the limit of the Automatic fine-leveling gimbal system.
PSEP Alignment	The astronaut will read and record to the nearest degree, the intersection of the shadow of the gnomon on the compass rose. Final azimuth alignment must be known within ± 5 degrees accuracy with reference to lunar North or South.
Interrelation	PSEP requires a clear field-of-view in order to obtain both thermal control and scientific data. PSEP must not be shaded from the sun on the lunar surface prior to deployment.

TABLE 4.1-2

LRRR DEPLOYMENT CONSTRAINTS

PARAMETER	CONSTRAINTS
LRRR Deployment Site	70 feet nominal from LM at a horizontal site. Astronaut will avoid craters and slopes.
LRRR Leveling	Must be leveled by astronaut within ± 5 degrees of vertical.
LRRR Alignment	Fine alignment will be performed by the astronaut. Final azimuth alignment must be known within ± 5 degrees of LRRR centerline.

TABLE 4.1-3

SWC DEPLOYMENT CONSTRAINTS

PARAMETERS	CONSTRAINTS
SWC Deployment Site	A reasonable distance from the LM that clears all structure or vented gases. Astronaut will avoid craters or slopes.
SWC Leveling	Must be emplaced on the lunar surface in a vertical position and facing the sun.
SWC Alignment	Alignment will be performed by the astronaut within <u>±</u> 30 degrees of the sun line.

4.2 DEPLOYMENT PROCEDURES

One man deployment is planned for the EASEP configuration based on the following assumptions and conditions:

- a. LM SEQ oriented toward the sun (lunar east).
- b. Commander and LM pilot maintain constant voice contact during deployment with each other and with MCC.
- c. The task sequence is based on information supplied by NASA Flight Crew Support Division on June 11, 1969.

Table 4.2-1 presents a task sequence for each astronaut during EASEP deployment. The time line is not presented in this table. It is expected that this deployment sequence will change as additional deployment exercises are performed by the astronauts.

CDR ACTIVITIES

LMP ACTIVITIES

SWC DEPLOYMENT

(At this time the CDR is deploying the TV, see Section VII)

Erect SRC table:

- a. Pull Velcro tabs to free table
- b. Pull table forward from stowed position and rotate into horizontal position
- c. Attach Velcro tape to hold table in correct position (level, fore and aft)

Pull the two straps holding SWC and remove SWC from MESA

Walk to sunlit area

Deploy SWC:

- a. Extend each section of staff until it locks (red band should be visible). Apply a compressing force to each section to check stations locked.
- b. Extend shade cylinder and rotate toward red side of pivot point, i.e., red to red.
- c. Extend foil shade and hook to lower portion of staff.
- d. Press staff into surface with foil normal to sun (side marked SUN to Sun)

Report status of -Y gear assembly:

- a. Main strut (take one photo)
- b. Secondary struts (one photo from each side)
- c. Pad/surface (take stereo pair)

Report status of -Y gear assembly:

- a. Main strut (take one photo)
- b. Secondary struts (one photo from each side)
- c. Pad/surface (take stereo pair)

EASEP DEPLOYMENT

(at this point the CDR is completing the LM inspection. See the preceding section)

Open SEQ bay door:

- a. Remove thermal cover from door lanyard.
- b. Retrieve lanyard from right side of SEQ bay (remove lower velcro strap).
- c. Move to position clear of door.
- d. Pull white portion of lanyard to raise door.
- e. Temporarily stow lanyard on strut.
- f. If Quad II is in a low attitude connect folded doors with velcro strap.

PACKAGES REMOVED BY BOOMS

Photograph package removal

Remove Package 1 (PSE):

- a. Retrieve boom lanyard from package (handle).
- b. Move to position clear of package (approximately 10 feet).
- c. Pull white portion of lanyard to unlock and move package from SEQ bay to fully extended boom position.
- d. Pull black and white striped portion of lanyard to lower package to surface.
- e. Release white portion of lanyard from base of package.
- f. Pull small lanyard (velcroed to handle) on package to release boom cable and lanyards. Reattach lanyard to velcro.
- g. Move Package clear.
- h. Pull black and white striped lanyard to retract boom (or push boom back with hand).

Remove Package 2 (LR³):

- a. Repeat Package 1 procedure (set package clear of SEQ bay).

MANUAL PACKAGE REMOVAL

Remove Package 1:

- a. Pull small lanyard, at top or bottom of package, to release hockey stick from boom.
- b. Remove deployment lanyard from package and pull white portion to unlock package from bay.
- c. Release white portion of lanyard from base of package.
- d. Move deployment lanyard to side clear of package.
- e. Manually pull package clear of SEQ bay.
- f. Set package on surface clear of bay area.

Remove Package 2:

- a. Repeat Package 1 procedure.

NOTE: Simultaneous accomplishment, although indicated of the following tasks, is not required.

Photo LMP and take close-up photos as practical.

Close SEQ bay door:

- a. Retrieve door lanyard.
- b. Move to position clear of door.
- c. Pull black and white stripe portion of lanyard until door is closed.
- d. Discard lanyard.

Select site for PSE and LR³ deployments, nominally 70 ft. south of the S/C.

Move to deployment site with cameras. Estimate distance and position with respect to the LM.

Carry PSE and LR³ to deployment site. (Nominally 70 feet south of the S/C. Report site location if it is not nominal.)

Place LR³ with base toward Earth. (Astronaut faces west for Sites 1 and 2 and east for sites 3, 4 and 5.) Rest/prepare area (clear rocks, smooth surface as required).

Place LR³ package on surface (on end) in a clear, level location, if practical. Move PSE approximately 10 feet further from LM and place on surface with base toward north (arrow on handle points to south).

Deploy LR³:

- a. Simultaneously grasp deployment boom ("hockey stick") and pull pin inside carry handle. Remove and discard "hockey stick"

①*

- b. Simultaneously grasp deployment handle and release ring (left side of package) to release deployment handle pull pin

②

- c. Pull deployment handle to extend handle six inches, to the first detent position, and to partially release array. Discard handle release ring.
- d. Grasp pull ring on array tilting handle, pull to remove protective cover. Discard cover ③
- e. Grasp deployment handle to steady package. ④A Grasp array tilting handle, push down rotate handle 45°. Pull outward to extend to detent position (9.5 inches) and complete array release ④B
- f. Use deployment handle to steady package. Use array tilting handle to tilt array (to detent for landing site).

Deploy PSE:

- a. Prepare area (move rocks, etc.) if required.
- b. From base of package pull lanyard to release gnomon ①
- c. Grasp carry handle with one hand and use the other to remove and discard the right solar panel-restraining pull pin ② and panel support bracket pull pin
- d. Grasp first solar panel support bracket, rotate bracket forward, lift bracket upward to release and remove first rear support bracket pull pin. ④ Discard bracket/lanyard/pull pin.

* The circled numbers and symbols correspond to decals on the packages.

- | | |
|--|---|
| <p>g. Release tilting handle (should spring back into stowed position).</p> <p>h. Depress trigger on deployment handle, pull handle to extend to full ⑤ extent (an additional 27 inches) and rotate package to lunar surface.</p> <p>i. Check and report experiment aligned and level to within $\pm 5^\circ$. ⑥ ALIGN Use gnomon shadow cast on partial compass rose for alignment. Use bubble for level indication. Use deployment handle to align and level as required.</p> | <p>e. Repeat procedures c. and d. for the left solar panel bracker ⑤ ⑥ ⑦</p> <p>f. From side of PSE pull deployment handle ("working height") pip pin ⑧ and remove "hockey stick" ⑨</p> <p>g. Grasp deployment handle, rotate and pull to extend to 30 inch working height and lock in place ⑩</p> <p>h. Use deployment handle to rotate package to surface.</p> <p>i. With deployment handle, embed package mounting tabs in lunar surface (smooth surface and align package ⑪ ALIGN</p> <p>j. Check and report experiment aligned and level to within $\pm 5^\circ$ as indicated by gnomon shadow cast on partial compass rose and bubble level, respectively. Use deployment handle to align and level as required.</p> |
|--|---|

Photograph scientific packages:

CAUTION:

Do not walk up-sun of the PSE. Shadows on the solar panels affect internal electronics.

- a. Take closeup photo of LR³
- b. Take stereo pair of LR³
- c. Take one photo from about same distance as stereo pair but at entirely different angle.
- d. Move to PSE
- e. Repeat photos as in a, b, and c.

- k. Pull antenna release lanyard from deployment handle (velcroed to handle) ⑫
- l. Pull lanyard to deploy solar panels and antenna.

NOTE: If the panels do not deploy, stand clear of deployment area and check rear support brackets clear of solar panels and release levers (underneath forward edge of panels) pulled

- m. Rotate antenna to designated landing offset (site dependent) ⑬
- n. Recheck package level and aligned. Report shadow on compass rose.

Move to the Quad IV area

Move to MESA with ALSRC. Take photos as practical. Photo footprint made while carrying EASEP.

Rest/check EMU

Rest/check EMU

5.0 GLOSSARY

ABBREVIATION

DEFINITION

A/D	Analog to Digital
AMU	Atomic Mass Unit
ASI	Apollo Standard Initiator
BxA	Bendix Aerospace Systems Division
CFE	Contractor Furnished Equipment
CM	Command Module
CS	Central Station
DS/S	Data Subsystem
EASEP	Early Apollo Scientific Experiment Package
EMU	Extravehicular Mobility Unit
EPS	Electrical Power Subsystem
FET	Field Effect Transistor
GFE	Government Furnished Equipment
GHz	Gigahertz
GSE	Ground Support Equipment
Hz	Hertz; Cycles per Second
IPU	Integrated Power Unit
IST	Integrated Systems Test
KHz	Kilohertz
KSC	Kennedy Space Center
LM	Lunar Module
LP	Long Period
LRRR	Laser Ranging Retro-Reflector Experiment
LSRL	Lunar Sample Receiving Laboratory
MCC-H	Mission Control Center-Houston
MSC	Manned Spacecraft Center
MSFN	Manned Space Flight Network
MSOB	Manned Spacecraft Operation Building
NASA	National Aeronautics and Space Administration
NRZ	Non Return to Zero

ABBREVIATION

DEFINITION

PAM	Pulse Amplitude Modulation
PCM	Pulse Coded Modulation
PCU	Power Conditioning Unit
PDU	Power Distribution Unit
PI	Principal Investigator
PSE	Passive Seismic Experiment
PSEP	Passive Seismic Experiment Package
RF	Radio Frequency
RFI	Radio Frequency Interference
RTG	Radioisotope Thermoelectric Generator
SBASI	Single Bridgewire Apollo Standard Initiator
SEQ	Scientific Equipment Bay in LM
SM	Service Module
SP	Short Period
SWC	Solar Wind Composition Experiment
USGS	United States Geologic Survey
VAB	Vertical Assembly Building